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**twins.** Twins have been mentioned since the beginning of recorded history, including ancient stories such as Romulus and Remus, the mythological founders of Rome, who were said to be twins abandoned and raised by a wolf. Although most mammals have large litters, primates including our species tend to have single offspring but occasionally have multiple births. Human twins are more common than people usually realize—about 1 in 85 births are twins. Surprisingly, as many as 20 per cent of all fetuses are twins but because of the hazards associated with twin pregnancies one member of the pair often dies very early in pregnancy.

Twins are of two types. One type, called identical twins, is derived from the same fertilized egg (called a zygote) that splits for unknown reasons to create two (sometimes more) genetically identical individuals. For about a third of identical twins, the zygote splits during the first five days after fertilization as it makes its way down to the womb. In this case, the identical twins have different sacs (called chorions) within the placenta. Two-thirds of the time, the zygote splits after it implants in the placenta and the twins share the same chorion. 'Siamese' twins are identical twins who split after about two weeks, timing that generally results in twins whose bodies are partially fused. Because identical twins come from the same zygote they are usually called monozygotic (MZ) in the scientific literature. The other type of twin involves two separate eggs that are fertilized by different sperm, just like any other brothers or sisters, and are called fraternal, non-identical, or dizygotic (DZ). About one-third of twins are identical twins. The identical twinning rate appears to be similar throughout the world and is not related to any demographic factors such as mother's age. In contrast, the fraternal twinning rate differs in different countries, and increases for older mothers, and may be heritable in some families. Fertility drugs have increased the rate of fraternal twinning by increasing the likelihood that more than one egg will be fertilized, as has *in vitro* fertilization in which several embryos are implanted in the hope that at least one will survive.

Twins are especially interesting today because of concerns about human cloning. Identical twins are more like clones than 'real' clones because identical twins spend their first nine months in the same womb and experience the same family environment and similar generational experiences. In contrast, if you were cloned from one of your cells, although your clone would be genetically identical to you, your clone would be raised in a different

womb, different family, and different generation. For this reason, your clone would be less similar to you than if you had an identical twin to the extent that such environmental factors are important. Identical twins are so similar physically that it is often difficult to tell them apart, especially when they are young. For example, identical twins have the same eye colour, hair colour and texture, similar fingerprints, their heights are usually within an inch, and their weight is within a few pounds. In fact, with greater than 95 per cent accuracy, you can tell if twins are identical simply by asking if they are easily confused, because this single question summarizes many physical characteristics that are highly heritable. (DNA is used to assess identical twin status with nearly 100 per cent accuracy—if twins differ for any DNA markers they cannot be identical twins.) Fraternal twins can look similar, as siblings sometimes do, but they do not look identical and are not often confused.

Identical twins are not only similar on the outside. They are also similar physiologically and psychologically. For example, if one identical twin has epilepsy, the chances are greater than 90 per cent that the twin partner also has epilepsy. Identical twin concordances for some other medical illnesses are 70 per cent for ulcers, 60 per cent for Alzheimer's disease, 50 per cent for rheumatoid arthritis, and 30 per cent for ischemic heart disease. For a few diseases, however, identical twins are not very similar, such as chronic obstructive pulmonary disease (15 per cent), breast cancer (15 per cent), and Parkinson's disease (10 per cent), which strongly suggests that susceptibility to these diseases is not much inherited.

Identical twins are at least as similar psychologically. For example, concordance for identical twins is about 60 per cent for autism, 50 per cent for schizophrenia, and 40 per cent for major depressive disorder. This evidence for genetic influence is not limited to disorders but also extends to behavioural differences between people within the normal range of variation. For example, identical twins are nearly as similar to each other in intelligence as measured by IQ tests as are the same individuals tested twice. For personality, identical twins are somewhat less similar than for physical traits and intelligence. The correlation is a statistic describing resemblance that runs from 0.00 indicating no more than chance resemblance within pairs of twins to 1.0 indicating that members of a twin pair are exactly the same. Identical twins correlate about 0.90 for height, about 0.80 for weight, and about 0.80 for IQ scores, but only about 0.40 for most personality traits.

What about your clone? As mentioned above, your clone could be considerably less similar than your identical twin if growing up in the same environment is responsible for making identical twins similar because your clone would not experience so similar an environment. The issue is the extent to which environmental factors are

responsible for the similarity of identical twins, which is the long-standing issue of nature (genetics) and nurture (environment). That is, it has long been known that family members resemble each other not just physically but also behaviourally. Do such traits run in families for reasons of nature or nurture? First described by Francis \*Galton in England in the late 19th century, the twin method compares similarity for identical and fraternal twins and has been the workhorse for disentangling nature and nurture. The twin method is the main reason why twins are so prominent in the scientific literature. The twin method is like an experiment in which one group (identical twins) are twice as similar genetically as another group (fraternal twins). If this twofold greater genetic similarity of identical twins has no effect on a trait, we would expect that identical twins would be no more similar than fraternal twins for the trait. Because half of fraternal twin pairs are opposite-sex twins, the experiment is better if same-sex fraternal twins are compared to identical twins, who are of course always of the same sex because they are genetically identical.

The twin method confirms, unsurprisingly, that individual differences in height are largely due to genetic differences: identical twins are highly similar for height (0.90) and fraternal twins are also just about as similar as expected on the basis of their genetic relatedness (0.45). You may be more surprised to learn that individual differences in weight are almost as highly heritable as height, with identical twin correlations of about 0.80 and fraternal twin correlations of about 0.40. The reason why the results for weight are more surprising than those for height is that you know that you can do more about your weight than you can do about your height. This raises an important point for interpreting results of twin studies. Finding evidence for genetic influence (often called heritability) does not refer to 'what could be': if you stop eating you will lose weight even though weight is highly heritable. Results of the twin method describe 'what is' in a particular sample rather than predicting what could be. That is, the twin method assesses the relative effects of genetic and environmental differences on

observed differences in weight as they exist for a particular sample given that sample's genetic and environmental differences at that time. If you change the genetics of the sample (for example, by studying different ethnic groups) or if you change the environment (for example, by providing fattier foods), you could change the relative effects of genes and environments. This explanation is also relevant to why there is no paradox that twin results show high heritability for height and weight even though height and weight have both increased considerably on average in developed countries in recent generations.

Results of twin studies of physiological and psychological disorders and dimensions also indicate that the resemblance for identical twins discussed above is almost entirely due to genetics, not to environment. The results of the twin method comparing identical and fraternal twins are supported by results from a few hundred pairs of identical twins reared apart which generally suggest that identical twins reared apart are nearly as similar as identical twins reared for psychological as well as physical traits. Thus, we can safely conclude that your clone would be almost as similar to you as would an identical twin. For some traits this means that your clone would be very similar to you – for height and weight and general physical appearance, susceptibility to certain diseases such as epilepsy and ulcers, and intelligence. For a few traits such as Parkinson's disease and breast cancer, there would be little resemblance. For most disorders and dimensions, however, your clone (or identical twin) would be moderately similar to you but would not be just a chip off the same old block. Moreover, research on twins suggests that despite their similarity there is no evidence that identical twins suffer from having a clone either physically or psychologically. For example, identical twins are just as intelligent and as well adjusted as non-twin individuals. Identical twins are clones and they are doing fine.

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